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Map Showing Zones of Similar Ages of Surface Faulting and Estimated Maximum Earthquake Size in the Basin and Range Province And Selected Adjacent Areas

by

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Introduction

Surface faulting in the Basin and Range province is accompanied by large earthquakes which, if they had occurred in highly developed areas, could have caused widespread damage. Historic faulting events such as the 1872 Owens Valley Earthquake (Bateman, 1961; Hill, 1972), the 1954 Dixie Valley-Fairview Peak earthquakes (Ryall and Van Wormer, 1980), the 1934 Hansel Valley Earthquake (Shenon, 1934) and the 1887 Sonoran Earthquake (Dubois and Smith, 1980) are typical examples. Enough information is now available about the distribution and age of prehistoric surface faulting events and the relationship of earthquake magnitude to fault rupture length to allow tentative distinction between areas of different surface faulting characteristics within the province. For example, in some parts of the province faults show common Holocene offset, whereas in other parts faults seem to lack surface faulting events since mid-Pleistocene time. Similarly, there are differences in lengths of faults, or, known or inferred lengths of surface rupture associated with prehistoric faulting. In this report we divide the Basin and Range province into zones based primarily on recency of fault movement following the technique developed by Wallace (1977a, 1977b, and 1978a, 1978b) and Bucknam and others (1980). The zones distinguish between areas of Holocene, late Quaternary, and no late Quaternary faulting. These divisions reflect differences in the history of high-magnitude earthquakes averaged over thousands of years. In addition we subdivide the Holocene category into zones characterized by recurrent Holocene movements on individual faults and zones where evidence of recurrent Holocene movements on faults is lacking.

Secondary zone boundaries are drawn to distinguish those areas that appear to share the same history of faulting but which differ in structural style and (or) estimated maximum magnitude.

The information summarized herein is expected to have a bearing on the development of seismic source zones in the Basin and Range province for mapping long return period (low annual exceedance probability) regional seismic hazards.

Sources of Information

Much of the information contained in this map was assembled at a series of regional seismic-source-zone meetings convened by the U.S. Geological Survey during 1979 and 1980. These meetings were structured as informal workshops consisting of small groups of regional experts (see list of participants at end of text) gathered together for the purposes of (1) presenting and discussing current research related to earthquake hazards within the regions, (2) speculating on the nature of the earthquake generating process on a regional scale, (3) voicing concerns and recommendations for various seismic source zones, and (4) suggesting treatment of these zones in application to probabilistic earthquake hazards maps. The positioning of many zone boundaries represent a general consensus following discussion among various individuals. Therefore, no single reference can be given to document these boundaries other than the meetings themselves.

Three of the meetings dealt with parts of the Basin and Range province as separate regions: the Great Basin, Northern Rocky Mountains and Southern Rocky Mountains. For areas within the Basin and Range province, the committees' definition of seismic source zones was based primarily on the age of latest fault displacement. Ongoing studies of faulting in the region by numerous investigators has provided data and interpretations that were not available at the time of the source-zone meetings. The present map reflects the incorporation of these new data and interpretations as well as the results of post-meeting correspondence and collaboration with numerous regional experts. Because further modifications can be expected in the future as research progresses, none of the zones boundaries can be considered absolute. Also no single committee considered the whole Basin and Range province which led to some inconsistencies and omissions. In order to present a coherent map, we have completed or modified some zone boundaries and resolved a few committee differences. Few committee decisions received unanimous support, and some encountered strong dissent.

The southeastern part of California, southwestern Arizona and southern Oregon were not considered in the meetings. We drew zones in these areas from information cited in the following zone descriptions.

Basis of Zone Boundaries

The zones in this report are broad regions that appear to be of similar general age of most recent surface faulting. A late Quaternary designation indicates that fault displacement leading to surface rupture has occurred within the the past half million years or so, but that no Holocene displacement is known. Where surface rupture is known to have occurred since formation of the shorelines of the great Pluvial lakes 15,000 to 20,000 years ago a Holocene (more stricty, post-pluvial) designation is assigned. The designation "no late Quaternary" is assigned to those zones where no conspicuous surface rupturing younger than about 500,000 years B.P. is known. The generally poor knowledge of alluvial stratigraphies in the Basin and Range province precludes a finer subdivision of age of latest fault displacement throughout most of the region.

Areas where Holocene surface rupturing has recurred on individual faults are separated by a primary zone boundary from areas where Holocene displacements appear to be caused by a single surface rupturing event. Faults having recurrent Holocene or recurrent post-pluvial displacements indicate average recurrence intervals of high magnitude earthquakes of less than about 10,000 years.

Secondary zone boundaries (dashed boundaries) distinguish those areas that share the same recency of faulting but which differ in structural style and (or) estimated maximum magnitude.

Estimated Maximum Magnitudes

The estimated maximum magnitudes assigned to the zones generally stem from the following observations of Wallace (1978b) and Bucknam and others (1980) that relate the dimensions of surface offsets in historic earthquakes in the Great Basin to earthquake magnitudes. (1) All historic events in the Great Basin M_L=6.3 or larger have produced surface faulting. (2) A surface rupture with at least 1 to 2 meters average vertical displacement and with a length on the order of tens of kilometers would be expected to produce an earthquake of about M_L=7. (3) Earthquakes having magnitudes greater than M_L=7 tend to be associated with dip-slip displacements of at least several meters.

These criteria have been applied throughout the Basin and Range province under the assumption that they apply to all faulting of late Quaternary age. Application of these criteria to fault scarps older than Holocene is complicated by ambiguity in identifying individual episodes of movement because of degradation of the scarps by erosion and deposition. It may be difficult, for example, to determine whether an older, sizeable scarp was formed by a few large vertical displacements or by more numerous small displacements. In areas of older faulting, therefore, more weight was given to length and continuity of faults in estimating maximum magnitudes than to the amount of surface offset. In zones of no late Quaternary faulting, either severe modification or complete obliteration of scarps preclude a statement on maximum magnitude according to the above criteria.

Most of the estimated maximum magnitudes assigned to zones, exclusive of the zones in southeastern California and southwestern Arizona, were assigned by committee at the seismic source zone meetings through general application of the above criteria. Although historical seismicity was not explicitly used as a basis for maximum magnitudes, the familiarity of the meeting participants with the historic record of large earthquakes assured implicit consideration of these events.

Bucknam and others (1980) related surface faulting to magnitude in terms of M_L which they assumed equivalent to M_s at magnitude levels greater than M=6 (S. T. Algermissen, oral communication, 1981). The estimated maximum magnitudes of this report represent surface wave magnitudes (M_s).

Zone Descriptions

Zone 1.--This zone is characterized by two historic earthquakes with associated surface disruptions in an area that otherwise exhibits late Quaternary faulting. Surface faulting was associated with the 1875 Mohawk Valley earthquake (Turner, 1896; Jennings, 1975; J. W. Bell, written communication, 1981). Ground cracking apparently due to shaking was observed following the September 12, 1966 Truckee, California earthquake (M 5.4, Kachadoorian and others, 1967). There was no apparent surface fault displacement (Kachadoorian and others, 1967; J. R. Filson, written communication *in* Von Hake and Cloud, 1968).

Zone 2.--This zone extends northwesterly along the Sierra Nevada-Great Basin boundary zone. Characteristic of the boundary zone in this area are en echelon warps and faults with recurrent Holocene offset (J. W. Bell, written communications, 1981, 1982; M. M. Clark, oral communication, 1982). The western boundary is poorly defined; in a general way, the zone encloses the western extent of the en echelon segments. Holocene scarps in the small part of Zone 2 north of Carson City, Nevada, show no clear evidence of recurrent Holocene movement (J. W. Bell, written communication, 1982).

Historic fault rupture associated with the Mammoth Lake, California earthquakes of May, 1980 is confined to the Hilton Creek Fault (M. Clark, oral communication, 1982; Clark and Yount, 1981). The length and continuity of the en echelon segments warrants a high maximum magnitude. The estimated maximum magnitude of 7.5 is consonant with the lower end of a range of 7.5 to 7.8 estimated by Ryall and Van Wormer (1980).

Zone 3.--Zone 3 extends south from Bishop, California to the Garlock fault and includes Owens Valley, Panamint Valley and Death Valley. Some faults within it exhibit recurrent Holocene faulting.

The mid-Owens Valley-Sierra Nevada fault zone broke at the surface during the 1872 Owens Valley earthquake (Bateman, 1961; D. B. Slemmons, written communication in Hill, M. R., 1972; estimated magnitude M=8, Ryall and Van Wormer, 1980). The ground rupture extended for nearly 160 km (Oakeshott and others, 1972). Similar long basin-border faults bound Panamint Valley and Death Valley. Twenty meters of Holocene right-slip with somewhat less dip-slip displacement has been documented on the Panamint Valley fault zone (Smith, 1979) and a right-slip component of movement is evident on the 1872 Owens Valley fault scarp on the west side of Owens Valley (Hobbs, 1910; Oakeshott and others, 1972; Bateman, 1961).

Zone 3 was given an estimated maximum magnitude of 8, consonant with that suggested by Ryall and Van Wormer (1980).

Zone 4.--This zone in northwest Nevada is characterized by widespread recurrent Holocene faulting (Wallace, 1977a, 1977b, 1978a, 1978b, 1978c; Slemmons, 1977; Bell, 1981, 1982). It includes the central Nevada Seismic Zone, which, despite its historic activity, does not appear from geologic evidence to be more active in prehistoric time than the rest of Zone 4.

Historic surface rupture has been areally confined to the Central Nevada Seismic Zone (Van Wormer and Ryall, 1980), however Holocene scarps are scattered over a much larger area. The northern part of Zone 4 includes the study area of Wallace (1977b, 1978c), who identified numerous Holocene scarps and estimated a rate of recurrence of large faulting events to be $3.4/10^4$ years per 10^4 square kilometers. The eastern boundary of Zone 4 is drawn to include Huntington Valley and the East Humbolt Range of northeastern Nevada. There, the Huntington Valley fault exhibits well-developed evidence of recurrent Holocene movement, as do some parts of the fault system that bounds the East Humboldt Range on the west. Scarps developed on range-bounding faults to the east and northeast of the East Humbolt Range appear to be older than Holocene, but are certainly late Quaternary in age (T. P. Barnhard, oral communication, 1981).

The northwest boundary of Zone 4 has been shifted northwestward from that drawn at the seismic-source-zone meeting (P. C. Thenhaus, unpublished data, 1981) in order to include recurrent Holocene movement on the Black Rock fault (Dodge and Grose, 1980), in the eastern Smoke Creek Desert (Bell and Slemmons, 1982b), and in the Surprise Valley area of extreme northeastern California (Hedel, 1980).

Zone 5.--The northern Walker Lane has geomorphic evidence of Holocene age surface rupture (Bell and Slemmons, 1982a). Definitive evidence of recurrent Holocene movement on individual fault traces within the Walker Lane is lacking, although this may be due only to insufficient study, particularly exploratory trenching (Bell, 1981; J. W. Bell, written communication, 1982). Holocene faulting occurs in the Susanville-Honey Lake area of northeastern California (L. T. Grose, oral communication, 1981). Faulting associated with the December 14, 1950 Fort Sage, California, earthquake extended about 9 km along the western slope of the Fort Sage Mountains with a maximum normal displacement of 20 cm (Gianella, 1957). The estimated maximum magnitude is the same as Zone 4 (M=7 1/2) (J. W. Bell, written communications, 1981, 1982).

Zone 6.--This zone exhibits no late Quaternary faulting (R. E. Anderson, oral communication, 1981).

Zone 7.--Through exploratory trenching studies Swan and others (1980) defined numerous episodes of surface faulting along the Wasatch fault zone in the past 13,000 years. Near Kaysville, Utah, at least three episodes of surface faulting have occurred since mid-Holocene time and at Hobble Creek six to seven events have occurred within the past 12,000 to 13,000 years. There has been no surface rupture along the Wasatch fault in historic time.

Swan and others (1980) estimate a magnitude of 6 1/2 to 7 1/2 for the Holocene events. Considering the length of the entire Wasatch fault zone, a maximum magnitude of 7 3/4 was assigned to the zone.

Zone 8.--The portion of Zone 8 west of the Wasatch fault zone is characterized by Holocene displacement on two faults (Bucknam and others, 1980). The 1934 Hansel Valley surface faulting followed a preexisting Holocene scarp (Bucknam and others, 1980) but recurrent displacements cannot be found on other scarps in the zone (R. C. Bucknam, oral communication, 1981).

Southeastern Idaho has well-developed extensional tectonic features, and faults in this area have the same basin-range character as elsewhere north and south of the Snake River Plain. Reconnaissance mapping of long fault scarps in the Bear Lake area (Idaho-Utah border) and the Palisades Reservoir area (Idaho-Wyoming border) indicates young faulting of probable Holocene age (A. Crone, oral communication, 1981). Scarp lengths are generally 30 to 60 km. The extension of Zone 8 south of the west end of the Uinta Mountains is based on stratigrahically dated Holocene offset on the Strawberry Fault north of Strawberry Reservoir (Nelson, 1982). Other faults betwen the Uinta Mountains and the Wasatch Fault however, have no known Holocene offset (A. R. Nelson, oral communication, 1982).

Zone 9.--Fault scarps in Zone 9 are short and have apparent vertical displacements of approximately 1 meter. These scarps are less likely to be Holocene in age than those to the north, but they are certainly no older than late Quaternary (A. Crone, oral communication, 1981).

Zone 10.--Zone 10 is taken from Bucknam and others (1980). Late Quaternary scarps are present, but Holocene scarps are not.

Zone 11.--This zone is characterized by six areas of Holocene faulting as defined by Bucknam and others (1980). The faults are fairly regularly spaced at about 50 km. The boundary, as drawn by Bucknam and others (1980), is at a distance to the Holocene faults equal to their average spacing. The scarps are thought to represent earthquakes of M_L=7 to 7 1/2 as they all have dip-slip displacements of at least 1 meter.

Zone 12.--No fault scarps in alluvium (Bucknam and others, 1980); that is, no faulting in at least late-Quaternary time.

Zone 13.--This zone encompasses the north-south trending set of normal faults that bound the Colorado Plateau on the northwest. There is evidence that faults in this area are listric and bottom at shallow depth in incompetant gypsiferous beds and salt formations (W. J. Arabasz, oral communication, 1981). The maximum magnitudes in Zone 13 may thus be lower than along transition faults bordering the Colorado Plateau, farther to the south; there the faults are probably more fundamental crustal features.

Zone 14.--Zone 14 defines two large irregular areas that include a variety of structural terranes characterized by late Quaternary faulting. In the north between 42°N and 43°20'N, the zone follows the northern margin of the Basin and Range province through southern Oregon. At the extreme northwestern tip of the province in southwestern Oregon, J. Smith (written communication, 1981) indicates that moraines younger than 70,000 years are offset by faulting. Also, on the southwest side of Upper Klamath Lake, cinder cones (estimated age 25,000 to 30,000 years B.P.) are offset by faulting. In the Goose Lake area of northeastern California, late Pleistocene shorelines are faulted, but no Holocene offset can be demonstrated (G. W. Walker, oral communication, 1981). Similarly, throughout southern Oregon, numerous Pleistocene scarps can be identified, but no Holocene displacements are known (G. W. Walker, oral communication, 1981). Locally, faults have been mapped in lacustrine sedimentary rocks of mostly middle or late Pleistocene age (Walker, 1977).

In the Raft River Basin, south of the Snake River Plain in Idaho, the youngest faulting episode does not disrupt stratigraphic units 200,000 to 300,000 years old (K. L. Pierce, oral communication, 1981). Based on soil and loess stratigraphy in trenches, the most recent faulting could be no younger than 200,000 to 300,000 years. A queried late Quaternary designation is given to this area on the map because it is possible that the faulting may be older than 500,000 years.

Between 38°N and 41°45'N Zone 14 extends through eastern Nevada and extreme western Utah and separates areas of younger faulting to the east and west (except for Zones 6 and 12) that extend to the margins of the province. In a general way, this pattern of zones reflects a tectonically quiet province interior bounded by tectonically active province margins. Because faults of the Central Great Basin in Zone 14 tend to be short, the maximum magnitude is thought to be lower there than at the province margins.

Between about 36°45'N and 37°30'N Zone 14 crosses the Southern Nevada Seismic zone which, despite a well-defined seismicity trend, exhibits no documented Holocene nor historic fault displacement.

The boundaries of Zone 14 that follow the California-Arizona border are poorly defined. This part of the zone is drawn to include three graben structures with known or suspected late Quaternary displacements. The Blythe graben, located at the southwest end of the Big Maria Mountains, can be mapped for about 3 1/2 miles. Latest displacements occurred between 31,000 to 6,000 years ago (Bull, 1976). The Chemehuevi graben located about 3/4 mile south of Havasu Lake is recognizable for 3 miles on areal photographs, but may extend an additional 7 miles beneath concealing alluvium (Woodward-McNeil and Associates, 1975). Trenching studies show 1 meter of displacement of an alluvial fan surface that is estimated to be no older than 500,000 years (Woodward-McNeil and Associates, 1975). Pleistocene displacements are associated with the Needles graben located several miles east of Needles, California (Woodward-McNeil and Associates, 1975). It is not clear from the description whether or not this faulting is younger than 500,000 years. From inspection of aerial photographs, Purcell and Miller (1980) indicate that the graben appears to break surficial deposits thought to be 30,000 to 100,000 years old. As no detailed work has been done on this graben, the age of latest fault displacement remains uncertain.

In southeastern Arizona, late Quaternary scarps are scattered and few (C. M. Menges, 1982; oral communication, 1981; Morrison and Menges, 1982; Schell and Wilson, 1981). Zone 14 continues eastward to include late Quaternary scarps west of the Rio Grande Rift in New Mexico (M. N. Machette, oral communication, 1981).

Zone 15.--Quaternary faulting in the western Grand Canyon region has been discussed by Anderson (1978). Hamblin and others (1981) documented recurrent displacement of a 290,000 year old basalt flow where the flow crosses the Hurricane fault near Hurricane, Utah. Due to the length and continuity of faults in the western Grand Canyon region, a somewhat higher maximum magnitude (M=7 1/2) is assigned than in Zone 14 to the west and southeast.

Zone 16.--Zone 16 follows the left-lateral Garlock fault. Clark and Lajoie (1974) postulated 85 m of Holocene displacement and Burke and Clark (1978) documented 9-17 faulting events in Holocene time. Clark (1973) documented widespread topographic evidence of Holocene displacement. Recent trenching studies indicate six Holocene faulting events on the eastern part of the fault (Roquemore and others, 1982). No historic tectonic movement on the fault has been recorded. The high maximum magnitude (M=8) is determined in part from the considerable length of the fault, but also from the fact that the fault rupture associated with the Kern County earthquake of 1952 (M=7.7, Murphy and Cloud, 1952) occurred on the White Wolf fault. That fault is parallel to the Garlock fault, and also has a left-lateral component of movement in addition to a major thrust component.

Zone 17.--Zone 17 is the central Mojave Desert Region. The boundaries of the zone conform to an area defined by Bull (1979) as an area of active tectonism. Bull (1979) has found evidence of multiple Holocene movements on the Lenwood fault and the Old Woman Springs fault. The Lenwood fault displaces a late Holocene surface by 1-1 1/2 meters (Bull, 1979).

Historic surface faulting was associated with the 5.2 magnitude Galway Lake earthquake of May 31, 1975 (Hill and Beeby, 1977). The fault zone had previous Quaternary displacements, perhaps in Holocene time (Hill and Beeby, 1977). The Manix fault within Zone 17 had historic surface rupture associated with the 1947 (M 6.5) earthquake (Woodward-McNeill and Associates, 1975), and surface rupture also accompanied the 1979, Homestead Valley earthquake swarm (Hill and others, 1980).

A maximum magnitude of M_s 7.5 has been estimated for this zone, analogous to the historically active portion of the Basin and Range province in western Nevada. This estimated maximum magnitude falls within a range of maximum magnitudes (Richter magnitudes) of 7 to 7 3/4 estimated for a number of faults within this zone (Woodward-McNeill and Associates, 1975).

Zone 18.--Zone 18, as defined by Bull (1979), is bounded by the Garlock fault to the north, the San Andreas fault to the west, and the active central Mojave Desert area to the east. Mountain fronts in this area have retreated several kilometers from their range-bounding faults whose traces are located in adjacent topographically low areas. In places upper Quaternary sediments are deformed, but not faulted, where they overlie basement faults perhaps indicating late Quaternary movement on the underlying fault (D. J. Ponti, oral communication, 1982). However, the deformation may be of an aseismic origin.

Zone 19.—Zone 19 includes the southern boundary of the Mojave Desert area as defined by Bull (1979). Although Bull (1979) included the southern boundary of the Mojave Desert in the tectonically active region based on numerous scarps of late Pleistocene age, the area lacks evidence of Holocene surface rupture.

Zone 19 includes the San Bernadino Mountains along the northern front of which late Pleistocene scarps are common (Bull, 1979). The zone also includes the Blue Cut and Pinto Mountain faults, which also have late Pleistocene, but no Holocene, movements.

The southern continuation of Zone 19 contains the enigmatic Sand Hills fault. This fault appears to be a southern extension of the San

Andreas fault that bounds the Imperial Valley on the east. The Sand Hills fault shows no evidence of Holocene rupture and is not associated with a pronounced seismicity trend as is typical of most major faults in the southern San Andreas fault system. Evidence of historic creep on the fault as shown by Jennings (1975) is equivocal (R. V. Sharp, oral communication, 1981). The Sand Hills fault is arbitrarily included in the late Quaternary zone.

The eastern boundary of Zone 19 is drawn directly northeast of Yuma, Arizona. There, northwest-trending scarps cut beds of latest Pleistocene age (15,000 to 60,000 years), but Holocene aeolian deposits are not disturbed (C. M. Menges, oral communication, 1981). South of Yuma, the Algondones fault has late Quaternary displacement (C. M. Menges, oral communication, 1981).

Woodward-McNeil and Associates (1975) assigned a maximum Richter magnitude of 7 to 7 1/2 to the Pinto Mountain fault and 6 3/4 to 7 1/4 for the Blue Cut fault, assuming a rupture of half their lengths. These estimates closely coincide with our estimated maximum magnitude of 7 1/2 for the region.

Zone 20.--Zone 20 includes the right-lateral San Andreas, Imperial Valley, Brawley, and San Jacinto faults, all of which have historic surface rupture. The Brawley seismic zone (G. F. Fuis and others, written communication, 1981; Fuis and others, 1981) connects the San Andreas fault to the Imperial and Brawley faults. This is based on alinements of epicenters and seismic refraction studies, however, rather than actual surface continuity of a fault trace.

The high estimated maximum magnitude is based on the 1857 Fort Tejon earthquake (M_s=8 1/4+) that was associated with 275 km of rupture along the southern San Andreas fault (Sieh, 1978).

Zone 21.--Zone 21 corresponds to the tectonically quiet area of the eastern Mojave Desert which has no known late Quaternary faulting (Bull, 1979; Schell and Wilson, 1982).

Zone 22.--Quaternary or perhaps Holocene age faulting offsets basalts of the Pinacate volcanic field in Mexico (San Diego Gas and Electric, 1976; Schell and Wilson, 1982). Quaternary faulting may extend into southwestern Arizona (San Diego Gas and Electric, 1976; Schell and Wilson, 1982) but data does not exist that would establish a late Quaternary age. One small, isolated scarp having late Quaternary displacement is located southeast of the Gila Bend Mountains in Arizona (C. M. Menges, oral communication, 1981; Schell and Wilson, 1982). No special consideration was given to this fault as it is small and occurs in such a broad area of no late Quaternary faulting.

Much of this zone lies within the integrated Colorado River drainage system where erosional denudation could remove evidence of early late Quaternary faulting.

Zone 23.--This zone represents Holocene faulting north of the surface faulting associated with the 1887 Sonoran earthquake (Herd and McMasters, 1982). The zone is based on evidence noted by M. N. Machette (oral communication, 1981) of one short Holocene scarp near the northern tip of the zone. Surface rupture associated with the 1887 Sonoran earthquake occurred on a fault that has evidence of a local surface rupturing event around 10,000 to 15,000 years B.P. And an event with accompanying surface rupture comparable to the 1887 earthquake at around 100,000 years B.P. (D. G. Herd, oral communication, 1981, 1982).

The estimated maximum magnitude of Ms=7.5 is based primarily on the size of the 1887 Sonoran earthquake (estimated magnitude 7.2, DuBois and Smith, 1980).

Zone 24.--The narrow east-west extent of Zone 23 is constrained on the west by a relatively large area of no late Quaternary faulting throughout Cochise County, Arizona (D. G. Herd, oral communication, 1981) and, on the east, by a somewhat smaller area of no late Quaternary faulting in extreme southwestern New Mexico (M. N. Machette, oral communication, 1981). The northern boundary of Zone 24, directly north of Zone 23, is approximately located.

Zone 25.--This zone encompasses the southern Rio Grande Rift area. Despite its large size, the Holocene age assignment is based on only four widely spaced Holocene faults which were reported by M. N. Machette (oral communication, 1981).

The east and west boundaries of Zone 25 closely follow the margins of the Rio Grande Rift as defined by Seager and Morgan (1979). The northern boundary of Zone 25 is based on a change in general structural style between the central and northern portions of the Rift as opposed to the southern part. The central and northern portions of the Rift are characterized by a regular, right-stepping echelon series of broad, north-trending basins. The southern portion of the Rift (Zone 25) is characterized by a pattern more typical of the Basin and Range. Deep basins in this area (as defined by Seager and Morgan, 1979) are parallel to sub-parallel in a northerly alinement and lack the right echelon pattern of basins to the north. Although individual basins in the southern part of the Rift are narrower in an east-west direction, their parallel arrangement results in an overall greater width of the whole Rift. The northern boundary of Zone 25 includes the Tularosa Basin and extends to the northwest to include the La Jencia fault that bounds the southern margin of the Albuquerque Basin. A maximum magnitude of 7 1/2 is based on 6 meters of Holocene offset on the La Jencia fault and the lengths of faults with Holocene age displacement being on the order of tens of kilometers in length (M. N. Machette, oral communication, 1981).

Zone 26.--Zone 26 encompasses the Albuquerque Basin that has reported, but undocumented, faulting of Holocene age. The zone has been given a queried assignment of Holocene.

Zone 27.--Zone 27 embraces the central and northern Rio Grande Rift. The rationale for the southern boundary of this zone is described under Zone 25. The high maximum magnitude is assigned because of the lengths of faults within the zone.

Zone 28.--This zone contains the Sangre de Cristo fault, which forms the northeast terminus of San Luis Valley. The fault shows geomorphic evidence of recurrent movement and, at one locality, offsets Holocene deposits (Kirkham and Rogers, 1981).

Zone 29.--This zone includes part of Trans-Pecos Texas in which no fault scarps cutting Quaternary units have been identified, but where major late Cenozoic Basin and Range faults offset lower Oligocene and older rocks (Muhlberger and others, 1978).

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APPENDIX A
GREAT BASIN MEETING
CONVENED OCTOBER 10-11, 1979
ATTENDEES

Ryall, A. S.	University of Nevada
Bell, J. W.	Nevada Bureau of Mines and Geology
Cluff, L. S.	Woodward-Clyde Consultants
Arabasz, W. J.	University of Utah
Algermissen, S. T.	U.S. Geological Survey
Anderson, R. E.	"
Bucknam, R. C.	"
Perkins, D. M.	"
Thenhaus, P. C.	"
Wallace, R. E.	"
Wentworth, C. M.	"
Zoback, M. L.	"

NORTHERN ROCKY MOUNTAINS MEETING
CONVENED DECEMBER 6-7, 1979
ATTENDEES

Rogers, W. P.	Colorado Geological Survey
Qamar, T. A.	University of Montana
Algermissen, S. T.	U.S. Geological Survey
Bucknam, R. C.	"
Kleinkopff, M. D.	"
McKeown, F. A.	"
Pakiser, L. C.	"
Perkins, D. M.	"
Reynolds, M. W.	"
Ross, D. C.	"
Schmidt, R. G.	"
Thenhaus, P. C.	"
Wentworth, C. M.	"
Witkind, I. J.	"

SOUTHERN ROCKY MOUNTAINS MEETING
CONVENED JANUARY 23-24, 1980
ATTENDEES

Dubois, S. M.	Ariz. Bur. of Geol. and Mining Tech.
Muehlberger, W. R.	University of Texas at Austin
Rogers, W. P.	Colorado Geological Survey
Sanford, A. R.	New Mexico Inst. of Mining and Tech.
West, M.	Water and Power Resources Service
Algermissen, S. T.	U.S. Geological Survey
Anderson, R. E.	"
Baltz, E. H.	"
Bucknam, R. C.	"
Dewey, J. W.	"
Irwin, W. P.	"
Jaksha, L. H.	"
Machette, M. N.	"
McKeown, F. A.	"
Perkins, D. M.	"
Scott, G. R.	"
Thenhaus, P. C.	"
Tweto, O. L.	"
Wheeler, R. L.	"